INQUIRY & INVESTIGATION

From Local to Global: A Birds-Eye View of Changing Landscapes

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NABT BioClub RECOMMENDATION

Biodiversity lessons in middle and high school science classes commonly focus either on sampling and analyzing an aspect of local ecological communities or on learning about an international issue such as rainforest destruction or coral reef degradation. Drawing connections between these geographical extremes is challenging, especially for students who have never traveled far from home. A common thread underlying local and international changes in biodiversity is landscape alteration, both human-induced and those triggered by natural events such as landslides and volcanic eruptions.

As part of a curriculum development project entitled Crossing Boundaries (http://crossingboundariesproject.org), we designed an inquiry-based activity that introduces students to landscape change and potential impacts on associated biological communities. Using pairs of current and historical satellite images (Figure 1), students explore landscape change in a variety of U.S. and international settings. Rather than engaging in a quantitative study of biodiversity, this exercise frames student thinking about a variety of landscape change agents and their potential effects on associated plant and animal communities. Students use Google Earth, a free software program, to fly from one location to the next on a virtual globe, exploring change over the past couple of decades at a variety of sites (Table 1).

Google Earth is becoming popular for classroom presentations and independent student explorations. The ability to "fly" in Google Earth's simulated three-dimensional environment to any location on Earth can open the door to global investigations. The activity described here uses 20 pairs of high-resolution historical and current satellite images that depict landscape changes in a variety of locations and biomes around the world. These images were selected from a larger collection compiled by the United Nations Environmental Program and published in print (UNEP, 2005), on the Web (http://na.unep.net/digital_atlas2/google.php), and within Google Earth's "Global Awareness" layer (click on the UNEP link in Google Earth). Each of these sources provides "before and after" pairs of images, accompanied with an explanation of the causes and impacts of the various examples of landscape change. Rather than providing these explanations, we created an inquiry-based activity in which students build their own interpretations through analysis of the paired imagery.

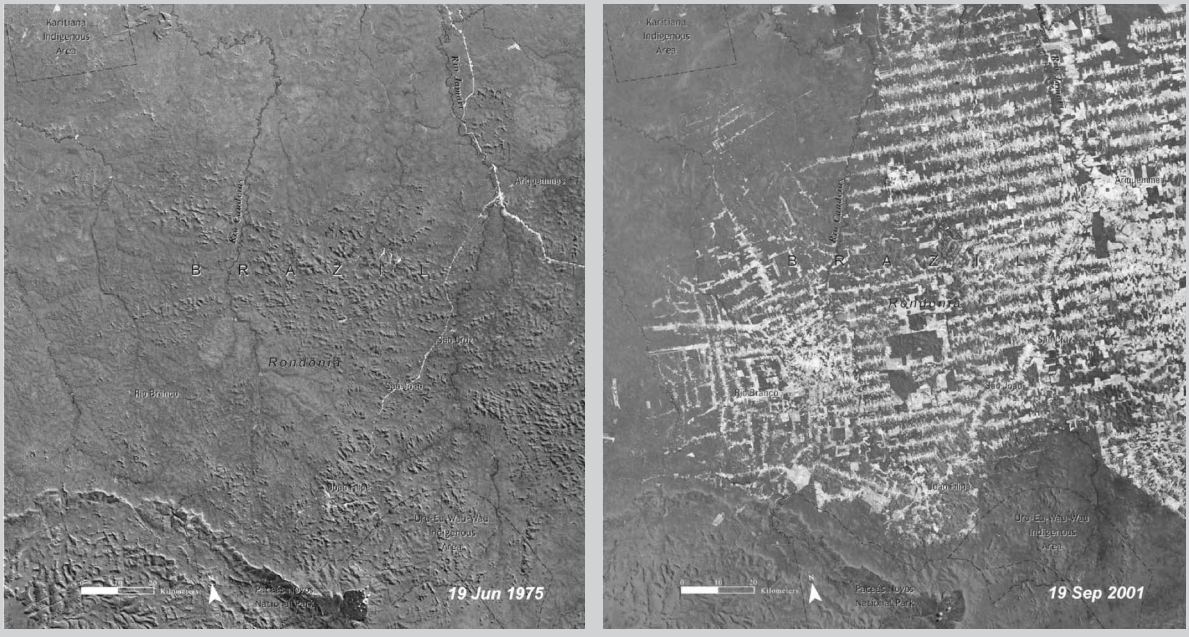


Figure 1. By comparing the two images of Rondônia, Brazil, in 1975 and 2001, students can observe the rapid deforestation that occurred over the time period, and begin to infer how these changes might impact biodiversity. Credit: United Nations Environmental Program, 2009.

Using Google Earth, students navigate from site to site. At each site, they use Google Earth's transparency function to switch back and forth between the "before" and "after" satellite images. Through analysis of these images, students observe both human and natural causes of environmental change and infer how such changes might affect the plant and animal communities at each site. Although Google Earth provides historical imagery at an almost endless number of sites around the world, the United Nations' paired imagery is particularly useful for this exercise because it was selected to represent a variety of causes of landscape change.

After pilot-testing this activity during a week-long professional development institute focusing on biodiversity, 21 New York State middle and high school biology and environmental science teachers completed an anonymous Web-based evaluation. Sixteen teachers (76%) rated the activity "very useful" and the remaining five (24%) rated it "useful." Discussion among these teachers indicated excitement about using the activity in a variety of ways – as an introduction before conducting local field-based biodiversity studies, as a wrap-up after conducting such studies, and especially as a way to build conceptual links between local studies and biodiversity issues on a global scale (Appendix: Teacher Perspective 1).

This activity addresses both content and process standards. National standards specify that middle and high school students should learn about the impacts of human activity on the capacity of the environment to support various forms of life (AAAS, 1993; NRC, 1996). Furthermore, the standards state that students "use appropriate tools and techniques to gather, analyze, and interpret data," identify evidence, create predictions, and "think critically and logically to make the relationships between evidence and explanations" (NRC, 1996, p. 145). In addition, students should discover the connection between population and environmental degradation (NRC, 1996).

This article presents the dual perspectives of the curriculum developers and an 8th grade science teacher (second author) in field-testing the activity with his middle school classes. Together we worked with five classes that included a total of 98 students. Earlier in the year, the students had learned about the interconnectedness of plant and animal species by studying trophic levels and food webs. They also had collected macro-invertebrates from a stream near their school and related the water quality to the types and diversity of organisms that they found.

Table 1. Geographic location of paired images within the Google Earth and a description of the environmental or landscape change occurring at each location.

SITE NAME	BRIEF DESCRIPTION
Aral Sea ***Kazakhstan & Uzbekistan***	Lake drying up
Copsa Mica ***Romania, Europe***	Pollution
Country Border ***Guatemala and Mexico***	Deforestation, agriculture & population increase
Green River ***United States***	Mining
Kara-Bogaz-Gol ***Turkmenistan***	Dam destroyed & water levels increase
Lake Cahora Basa ***Mozambique***	Dam construction
Lappi – Finland ***Finland***	Deforestation
Mabira Forest Reserve ***Uganda***	Deforestation around a national park
Manaus ***Brazil***	Deforestation & urban area
Mt. St. Helens ***United States***	Volcano
Peanut Basin ***Senegal***	Abandoned agriculture
Powder River Basin ***United States***	Mining
Rondônia ***Brazil***	Deforestation & agriculture
Santa Cruz ***Bolivia***	Deforestation & agriculture
Shenzhen ***China, Asia***	Urban growth
Three Gorges Dam ***China***	Dam construction
Virunga National Park ***Congo***	Deforestation around a national park
Walvis Bay ***Namibia, Africa***	Salt pond construction
Weipa Bauxite Mine ***Australia***	Mining

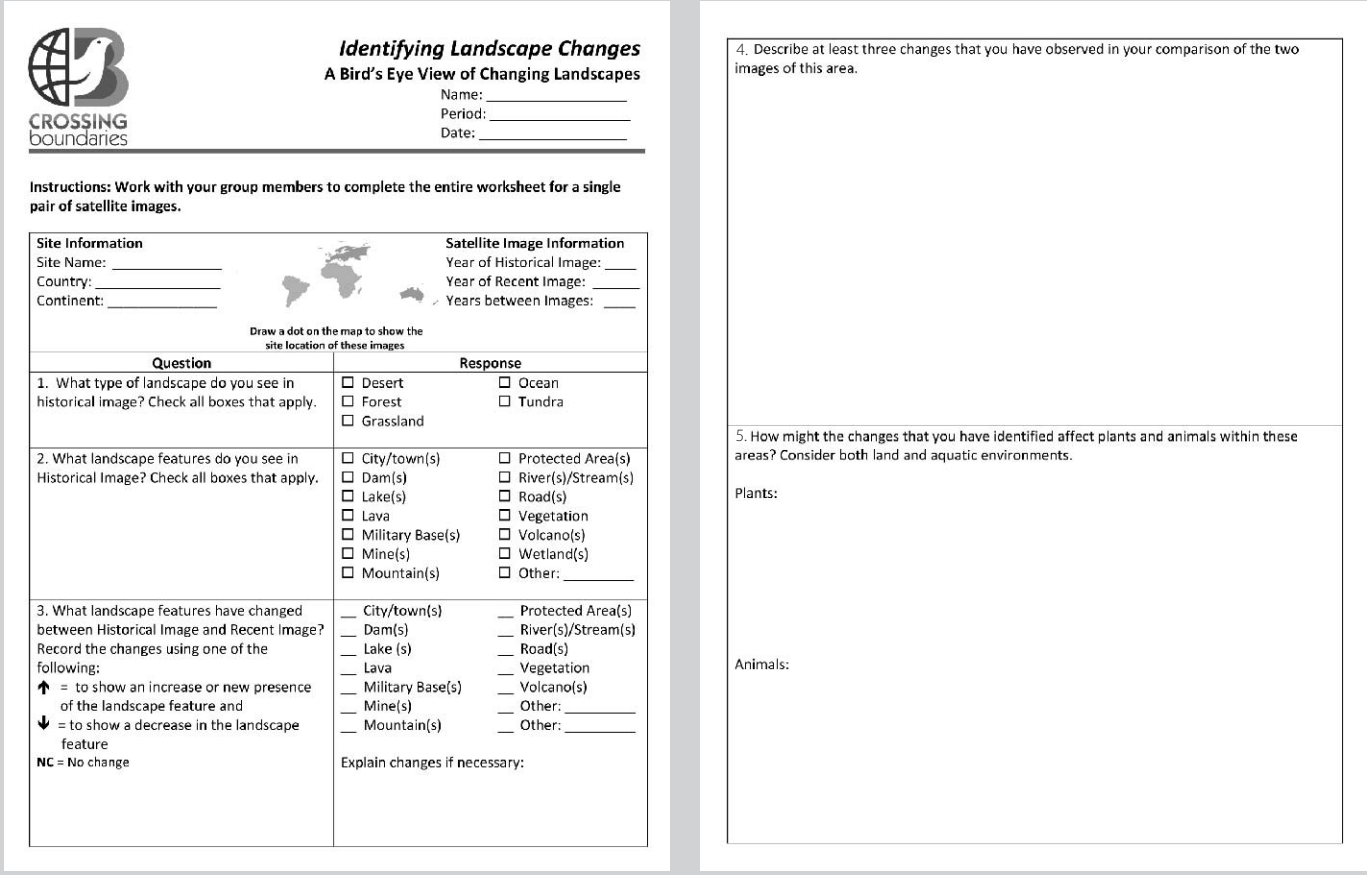
○ Learning Objectives

Students will be able to:

1. interpret land use and land cover changes as documented by satellite imagery.
2. make inferences about the causes of landscape change.
3. discuss the potential impacts of landscape change on associated plant and animal communities.

○ Materials

- Computers connected to the Internet
- Google Earth – Version 5 (available for free download at http://earth.google.com)
- Google Earth Biodiversity Investigation (available for download at http://crossingboundariesproject.org/ge/biodiversity.html)



CROSSING boundaries

Identifying Landscape Changes

A Bird's Eye View of Changing Landscapes

Name: _____
Period: _____
Date: _____

Instructions: Work with your group members to complete the entire worksheet for a single pair of satellite images.

Site Information	**Satellite Image Information**
Site Name: _____	Year of Historical Image: ____
Country: _____	Year of Recent Image: _____
Continent: _____	Years between Images: ____

Draw a dot on the map to show the site location of these images

Question	Response
1. What type of landscape do you see in historical image? Check all boxes that apply.	☐ Desert ☐ Ocean ☐ Forest ☐ Tundra ☐ Grassland
2. What landscape features do you see in Historical Image? Check all boxes that apply.	☐ City/town(s) ☐ Protected Area(s) ☐ Dam(s) ☐ River(s)/Stream(s) ☐ Lake(s) ☐ Road(s) ☐ Lava ☐ Vegetation ☐ Military Base(s) ☐ Volcano(s) ☐ Mine(s) ☐ Wetland(s) ☐ Mountain(s) ☐ Other: _____
3. What landscape features have changed between Historical Image and Recent Image? Record the changes using one of the following: ↑ = to show an increase or new presence of the landscape feature and ↓ = to show a decrease in the landscape feature **NC** = No change	__ City/town(s) __ Protected Area(s) __ Dam(s) __ River(s)/Stream(s) __ Lake (s) __ Road(s) __ Lava __ Vegetation __ Military Base(s) __ Volcano(s) __ Mine(s) __ Other: _____ __ Mountain(s) __ Other: _____ Explain changes if necessary:

4. Describe at least three changes that you have observed in your comparison of the two images of this area.

5. How might the changes that you have identified affect plants and animals within these areas? Consider both land and aquatic environments.

Plants:

Animals:

Figure 2. Investigating Landscape Change Worksheet. To view another version of the worksheet better suited for high school and undergraduate audiences, see http://crossingboundariesproject.org/ge/biodiversity.html.

- Identifying Landscape Changes Worksheet (available for download at http://crossingboundariesproject.org/ge/biodiversity.html)

Note: The complete lesson plan is also available for download at http://crossingboundariesproject.org/ge/biodiversity.html

○ The Activity

Class One: Introduce Students to Local Environmental Change

As an introduction to interpreting satellite images, students used Google Earth to find their own town. It was suggested they use major geographic features such as the Great Lakes as reference locations. After demonstrating how to activate historical imagery in Google Earth, we (first and second author) asked the students to identify the types of changes that had occurred in their home community during their lifetime, the past 13 years (Appendix: Teacher Perspective 2).

The students were inquisitive about the changes that had taken place so close to home, especially in relation to the establishment of a new Walmart. Comparing historical and current local satellite imagery, students saw changes at the mouth of the stream they had sampled, the wetland into which the stream flowed, and a variety of other locations. Each team created a table to record land use changes and hypothesize about possible effects in their local watershed. Observations included a decrease in vegetation, increase in impervious surfaces, and expansion of a local mine. These observations led the students to infer decreased water filtration by wetlands, increased runoff of motor oil and other chemicals, and decreased habitat for local wildlife. Following class discussion of these observations and inferences, the students completed the Identifying Landscape Changes Worksheet (Figure 2).

Class 2: Engage Students in Exploration of Regional Environmental Changes Using Skills Learned From the Previous Local Exploration

After exploring satellite interpretation of familiar features in their local community, the students used Google Earth to travel virtually to Las Vegas, Nevada, a setting unfamiliar to them but still somewhat recognizable (Figure 3). To provide historical context for the urban growth there, we told students about the construction of Hoover Dam. This led to discussion of changes that resulted from massive irrigation efforts within a desert environment.

Using the Identifying Landscape Changes Worksheet, students recorded changes that had occurred in Las Vegas between 1973 and 2006. The predominant change was expansion in area covered by buildings, mining, housing, golf courses, and roads. Students inferred that this development almost certainly decreased the native vegetation and wildlife, but also could have increased the population of non-native plants and animals that would have been unable to survive in a desert environment.

Class 3: Discover Environmental Change Around the World

The Google Earth file used in this activity represented scenarios including deforestation in Brazil, abandoned agriculture fields

Figure 3. Las Vegas, Nevada, has experienced high population growth over the last quarter century. The transparency bar in Google Earth enables students to easily switch back and forth between historical and current satellite images in Google Earth. Credit: United Nations Environmental Program, 2009.

in Senegal, and lowering of the water level in Kazakhstan's Aral Sea. Using interpretation skills developed through analysis of satellite imagery of their hometown and Las Vegas, students investigated imagery of other sites around the world, using the Identifying Landscape Changes Worksheet to record their observations. Students flipped back and forth between historical and current images, zooming in and out to examine areas of interest and uncover potential causes of the changes they observed. Some students decided to extend their investigations using Google Earth Primary Database Layers such as roads or the geographic web. Others investigated land beyond the study site to gather clues from surrounding regions. Student pride was evident when they identified key pieces of evidence such as the dam that created Lake Cahora Basa in Mozambique, or the flows of volcanic lava that dramatically changed the landscape at Mount Saint Helens (Appendix: Teacher Perspective 3).

After completing their investigations, student teams presented their findings. In this case, they projected the paired images onto the classroom ActivBoard; however, presentations could be done using a regular projector and screen as well. Student presentations addressed the following questions about biological communities and the relevance of the satellite imagery:

1. What landscape changes did you notice?
2. How might these changes affect communities of plants and animals in this area?
3. How might scientists and government officials use the information you have compiled?

○ Evaluation & Results

Using completed worksheets and in-class presentations, we evaluated students' skill in interpreting satellite imagery and ability to infer potential causes of observed landscape change and project potential impacts on biological communities. All of these learning objectives were met satisfactorily. Worksheet scores ranged from 75% to 100%, reflecting high levels of understanding and effort. Some students demonstrated higher-order thinking as they sought to predict consequences of land use change. For example, a pair of typically high achieving students who observed water level change in Kazakhstan's Aral Sea inferred that "the cities and towns [around the sea] are growing ... [and] taking the water for irrigation, which is ruining the desert habitat and turning this land into crop fields. This affects the sea life because their habitat is dramatically decreasing."

The activity also caught the interest of students who tended to be disengaged during traditional classroom activities. For example, two C-average students achieved scores of over 90% for their work on this activity, and their teacher remarked at this unusual level of interest on their part. After examining the expansion of Mexico City, this pair discussed their concern for the native plant and animal communities due to the spread of buildings into the predominantly desert environment. During their presentation, a classmate proposed creation of parks to preserve the desert habitat.

Most of the students were captivated by the use of satellite imagery (Appendix: Teacher Perspective 4). One pair of students was motivated to go beyond the assignment and spend time at home investigating why the tropical forest in Bumba, Democratic Republic of Congo, had grown back after deforestation. This pair of students discovered a link between social and environmental issues and presented this finding in class the next day:

Over the years a civil war broke out within the community that caused people to move to other places and countries, therefore all of the forest grew back because there weren't any people inhabiting them. ... Because of fewer people living there the environment is better – the forest had come back, but civilization is much worse.

The presentations displayed significant student ownership of their findings. Using the ActivBoard to "fly" their peers to their study sites, students gave animated accounts of changes they had observed. Pointing to the southern coast of China, three students with learning disabilities and generally low self-confidence energetically shared their observations related to the city of Shenzhen. They inferred a decrease in water filtration from a shrinking area of forest, an increase in residential and commercial runoff into the South China Sea as a result of the growing city size, and a decrease in habitat for aquatic life due to filling in the South China Sea to create a harbor.

Overall, the students' presentations indicated that they had accurately interpreted the images and identified plausible impacts of change on biological communities. Defending their perspectives and responding to questions provided further opportunities for students to demonstrate the depth of what they had learned.

○ Implications for Teaching

Our field testing of this activity confirmed that Google Earth, coupled with the United Nations Environmental Program's paired satellite imagery, provides a powerful motivational tool that helps students understand the relationships between land cover and biological life. Middle school students at all ability levels were captivated with the chance to explore both their home community and distant sites from a new perspective (Appendix: Teacher Perspective 5). The interactive features of Google Earth engaged students in a way that textbooks and videos do not, helping them to learn ecological concepts through analysis of real-world imagery.

This activity could be adapted for use at high school and undergraduate levels, with greater sophistication in analysis expected at the higher grades. Use in high school science would help to meet the standard that 12th grade students will know that :

The human species has a major impact on other species in many ways: reducing the amount of the earth's surface available to those other species, interfering with their food sources, changing the temperature and chemical composition of their habitats, [and] introducing foreign species into their ecosystems. (AAAS, 1993, p. 57)

This activity can set the scene for meaningful local fieldwork or investigation of global biological conservation issues (Appendix: Teacher Perspective 6). Exploring land use allows students to learn how to interpret satellite imagery, a highly valued skill in the 21st century (http://www.doleta.gov/Brg/Indprof/Geospatial.cfm), and to use higher order thinking consistent with the *National Science Education Standards.*

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BIO

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APPENDIX. Teacher Perspective Boxes

Teacher Perspective 1

This activity is within reach of any teacher regardless of their technological comfort level. Without exception, students come into my room adept at the computer. With properly sequenced instructions, they can travel around the world to explore environmental changes. In my experience, working in partners is a marvelous way for students to help each other.

Teacher Perspective 2

Learning comes naturally when it begins with the familiar, allowing what is known to be an entrance into the unknown. My students began this unit with an investigation into their own community. They looked at the condition of the local environment and how human activity affected its condition. From this we examined new locations around the world with an eye made comfortable by our own local experiences.

Teacher Perspective 3

This technology is opening up the world to my students. I am not only talking to my students about changes in our community, I am talking about the expansion of the harbor in Shenzhen, China and the development of logging roads in Rondônia, Brazil. As such, this experience provides an important opportunity for students who might not have the opportunity to travel to these areas. In my classroom many students have not crossed the county border, let alone traveled outside their own state or country.

Teacher Perspective 4

One of the strengths of the activity is that each student was able to identify his or her own dramatic examples from the images. The students searched until they found their own "aha" moment. If the images didn't win their hearts immediately, they went to another spot. It was obvious that the curriculum was engaging because of the content, but also because it used seductive technology. Google Earth does pull everyone in. It pulls everyone in to unlocking the biological community story within the "before" and "after" images.

Teacher Perspective 5

If we want our students to be global we first need to make them aware of the local. We have more than enough local issues...loss of habitat, contamination of streams, over use, human activities both positive and negative...it is all here. It is engaging and that is the critical piece. This activity clarifies why plant and animal communities are important throughout the world.

Teacher Perspective 6

Environmental mechanisms that maintain stability are based on key principles that are revealed in everyone's own backyard. Whatever is discovered by my students locally is readily applied globally. The former Speaker of the House, Tip O'Neil of Massachusetts, once said that, "All politics is local". I think the same applies to the steadying mechanisms within the environment. By looking at how a local shopping center impacts a watershed in our community, my students can realize for themselves how human activity elsewhere in the world works for or against environmental stability.